

Inter Swath Data Quality Measures to Assess Quality of Calibration of Lidar System



Outline

- **Introduction**
- **Inter Swath Analysis**
- **Internal Data Quality Measures**
- **Prototype Research Software for DQM**
- **DQM Test and Analysis**
- **Concluding Remarks and Discussion**

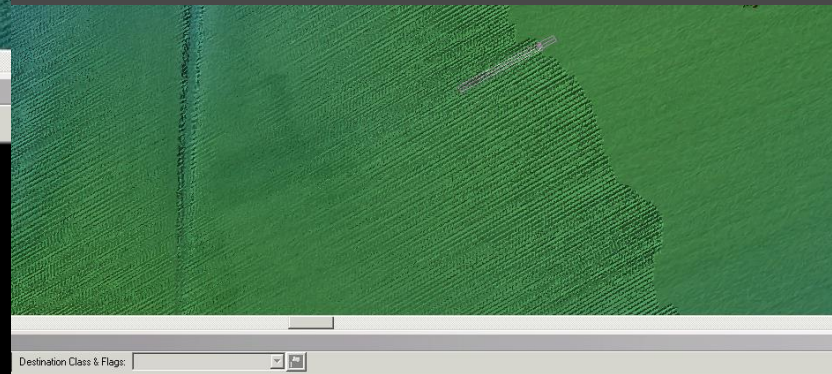
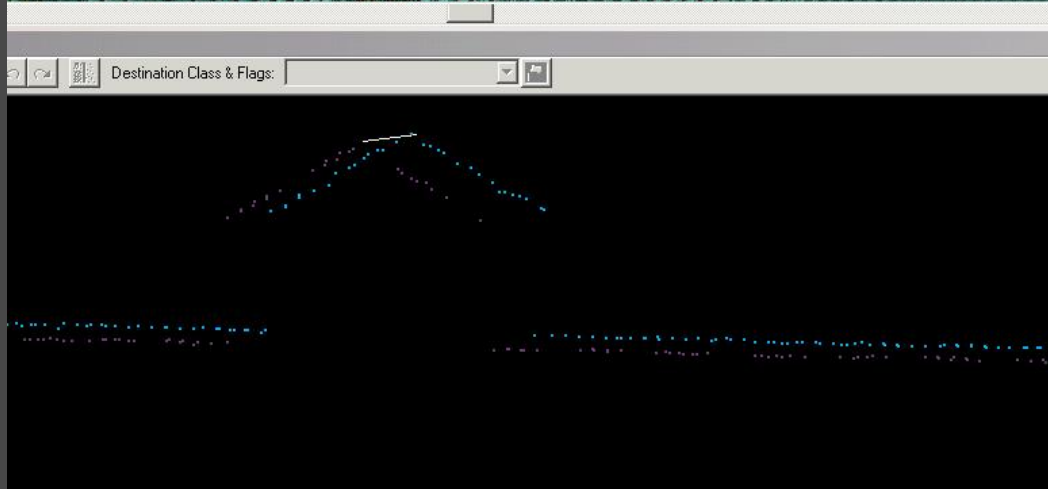
Introduction

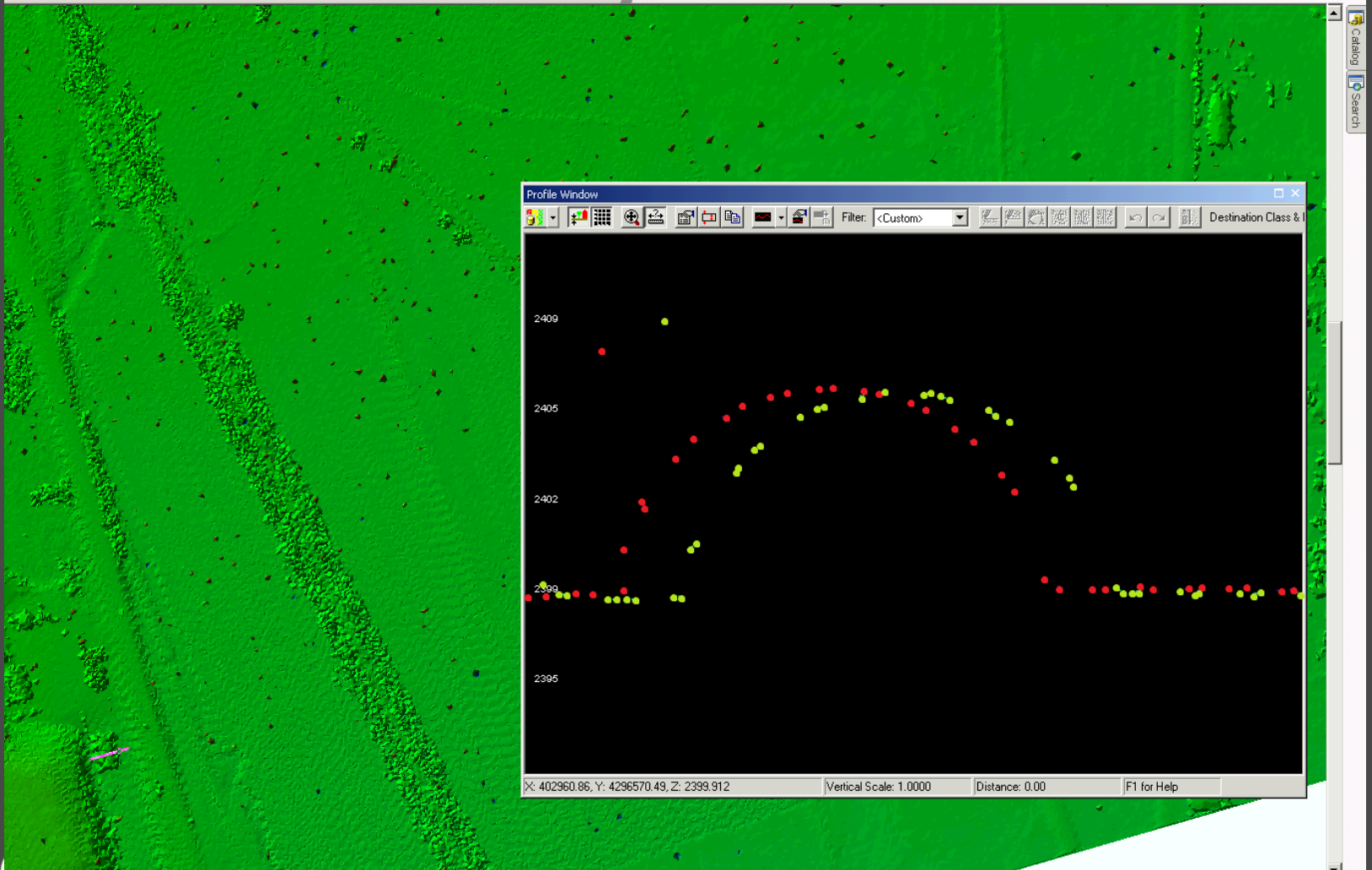
- **Airborne Lidar data have become the primary means of 3D mapping**
 - Quality standards transform Lidar point cloud from pretty visualization to metric data
- **Quality control and assurance processes are not consistently applied and available**
 - Algorithms and Tools to analyze quality of point cloud are necessary
- **For national projects as 3DEP consistent geometric quality assessment methods needed**

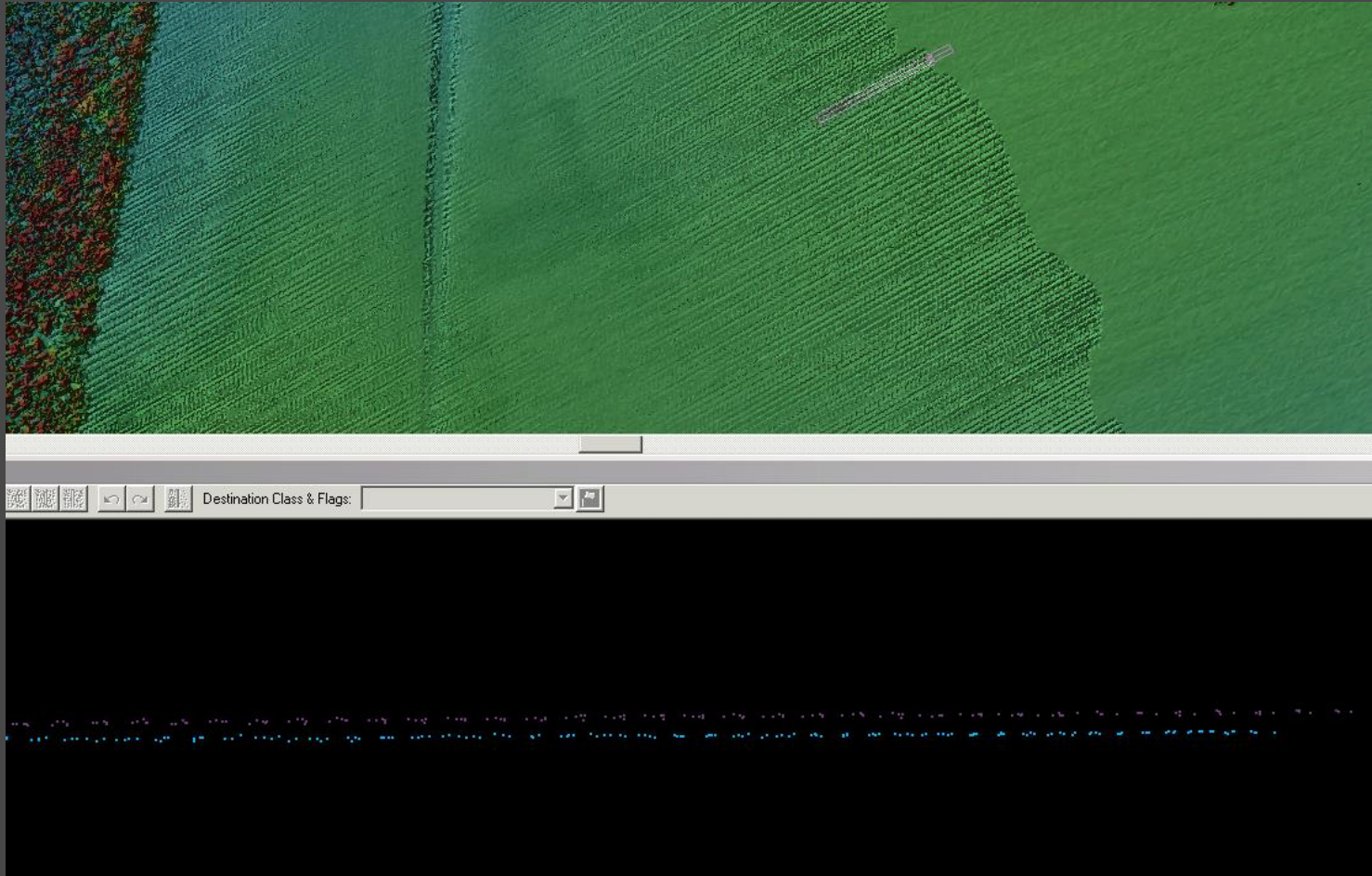
3DEP

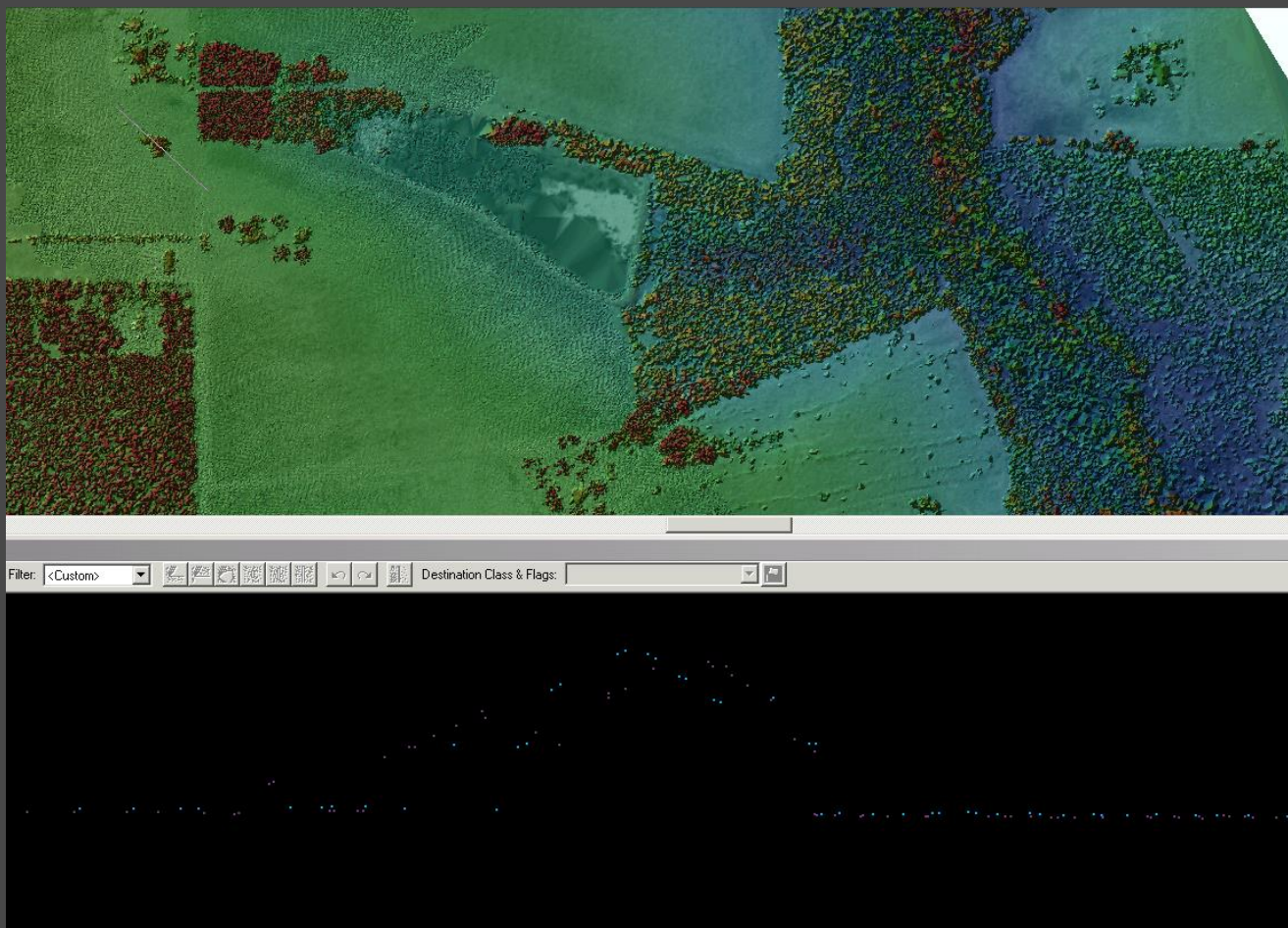
- **3DEP will collect 3D data over the entire US**
 - Lidar is the technology of choice
 - Many data providers, sub contractors etc.
 - Data should be of consistent and known quality
 - Important to have tools to test quality of Lidar/3D data
- **Lidar System involves integration of complex systems (sensor, IMU, GPS etc.)**
 - Errors in consistency are inevitable..
 - Comprehensive data consistency measurement specifications a must to minimize errors

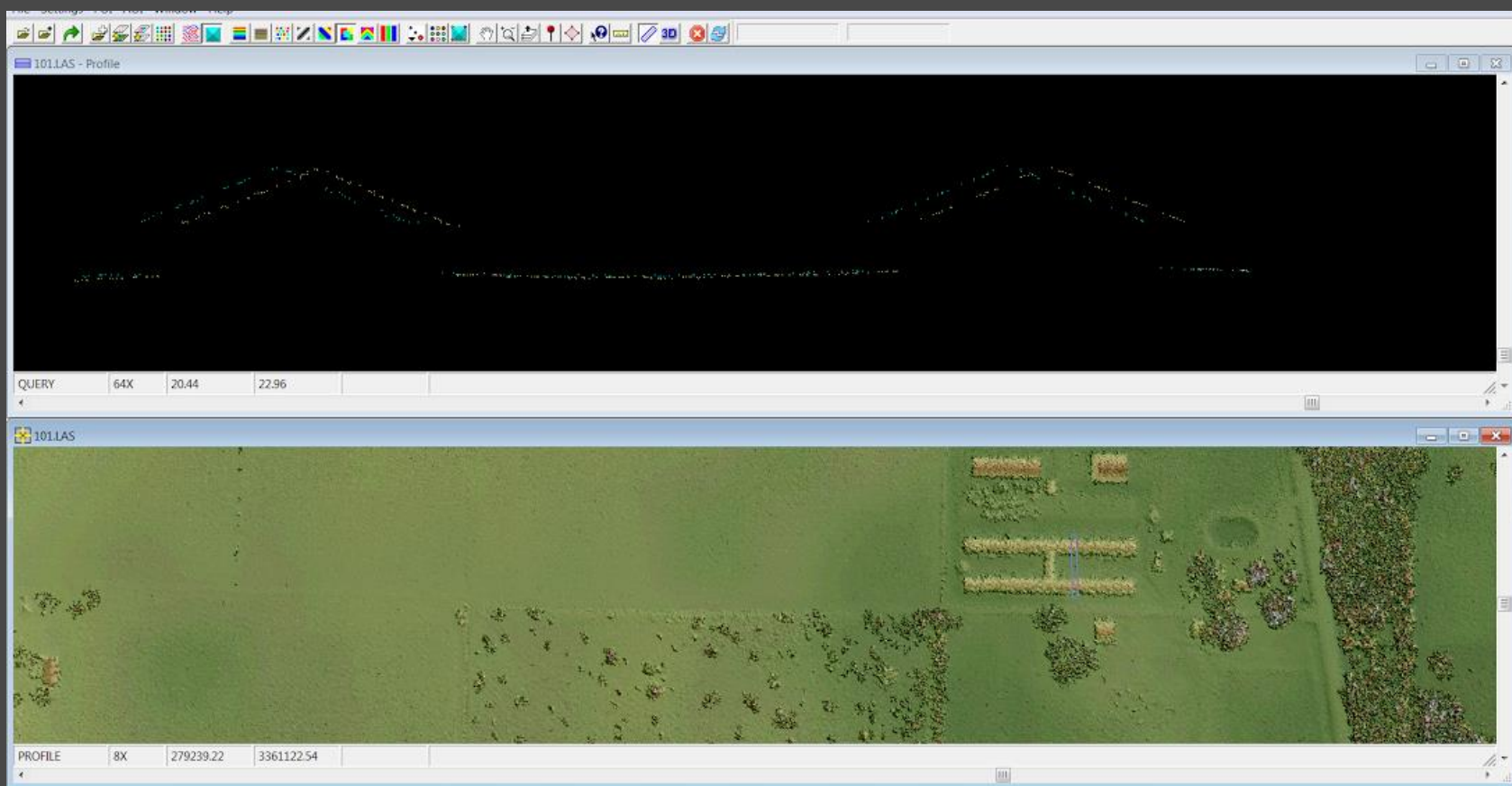
Sample Errors present in accepted Lidar data

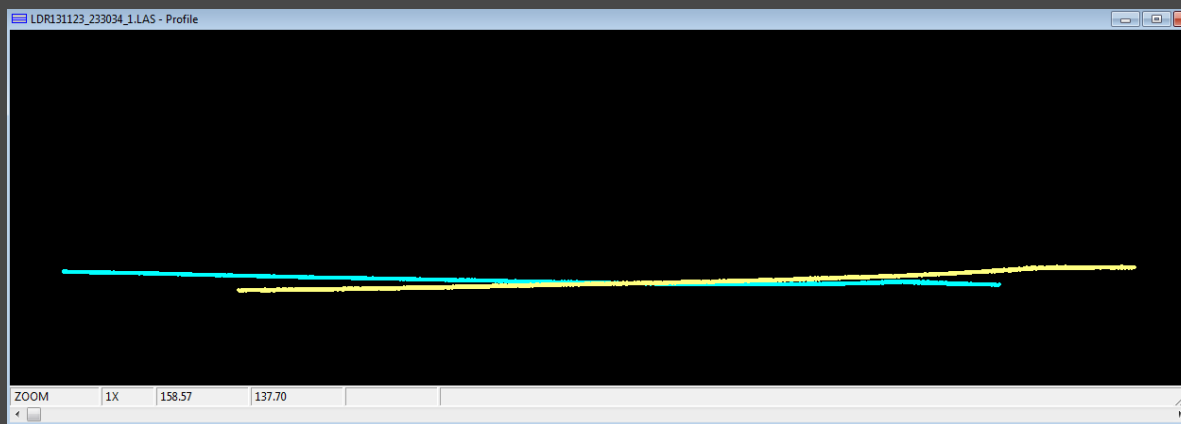
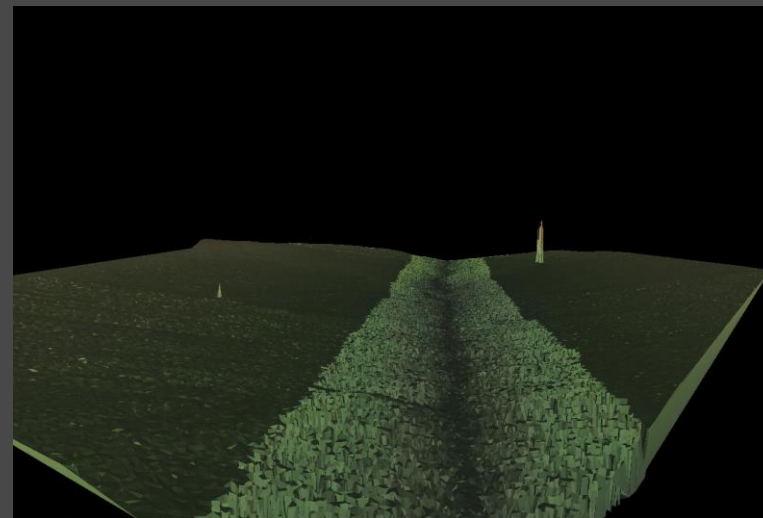
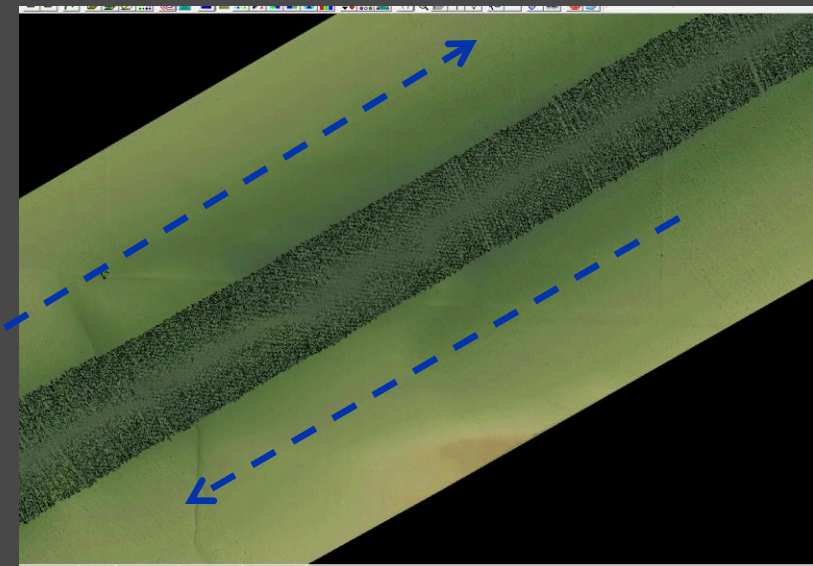








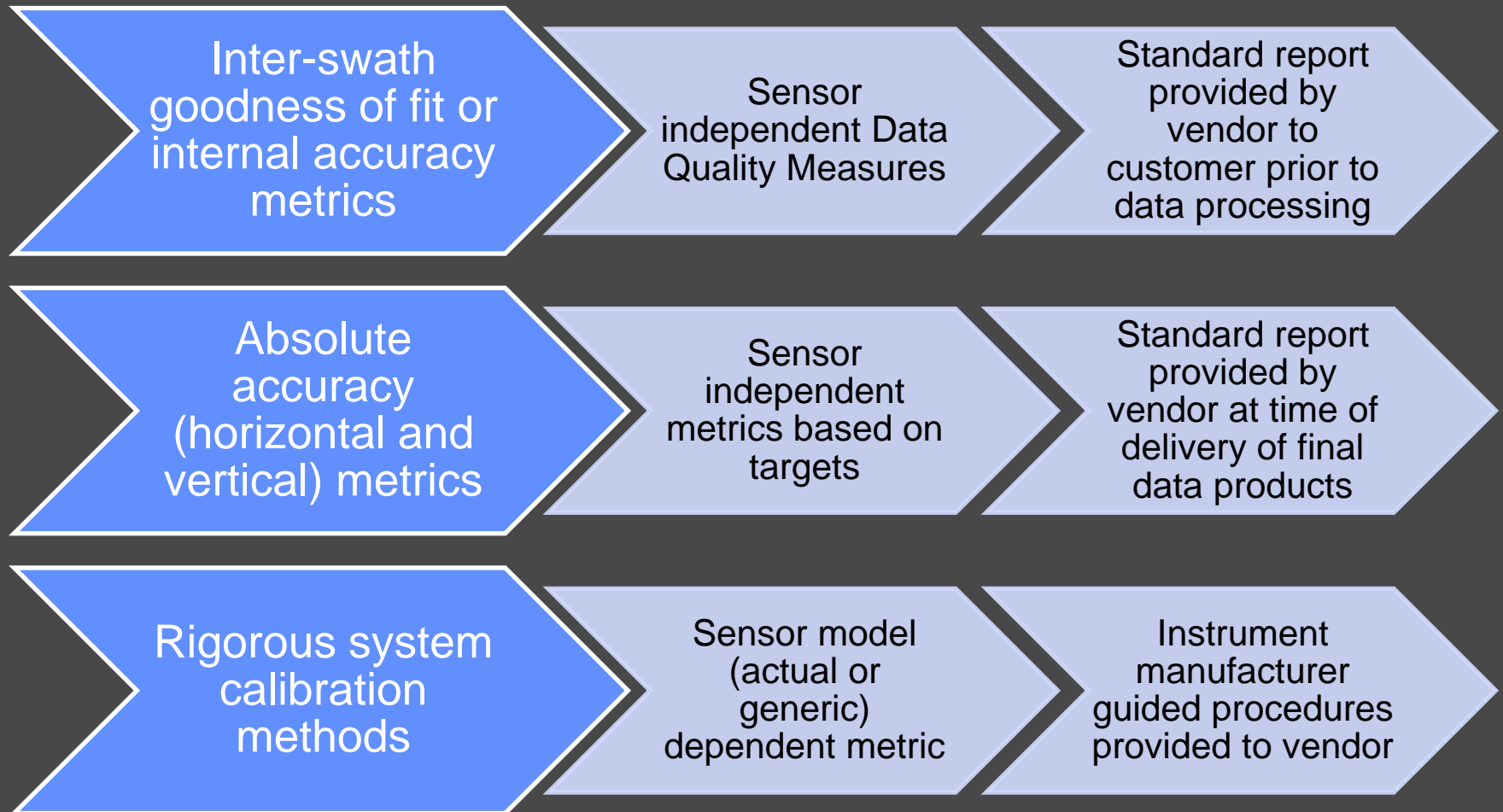




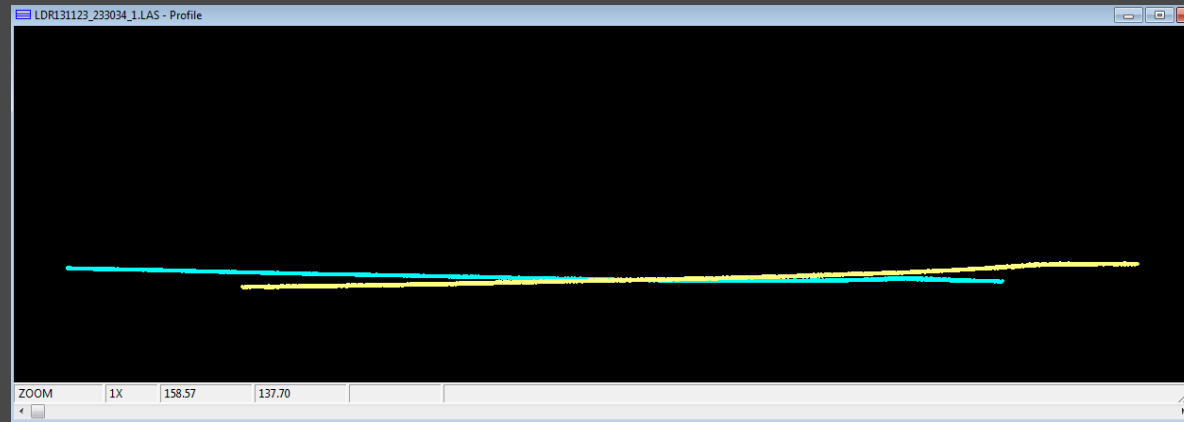
USGS-ASPRS Lidar Cal/Val Working Group

- **ASPRS Airborne Lidar Committee has formed a working group of:**
 - Industry - Instrument Manufacturers, Data providers, and Data users
 - Government (USGS, NGS/NOAA, US Army corps, NGA, etc.)
 - Academia (Ohio State, University of Calgary, Purdue, etc.)
- **Develop and publish guidelines on assessing geometric accuracy of Lidar data**
 - Relative (Internal) Quality Control Processes and Report
 - Absolute (external) Quality Control Processes and Report
 - Recommended Quality Assurance Guidelines

Framework for Guidelines Document



Inter Swath Accuracy

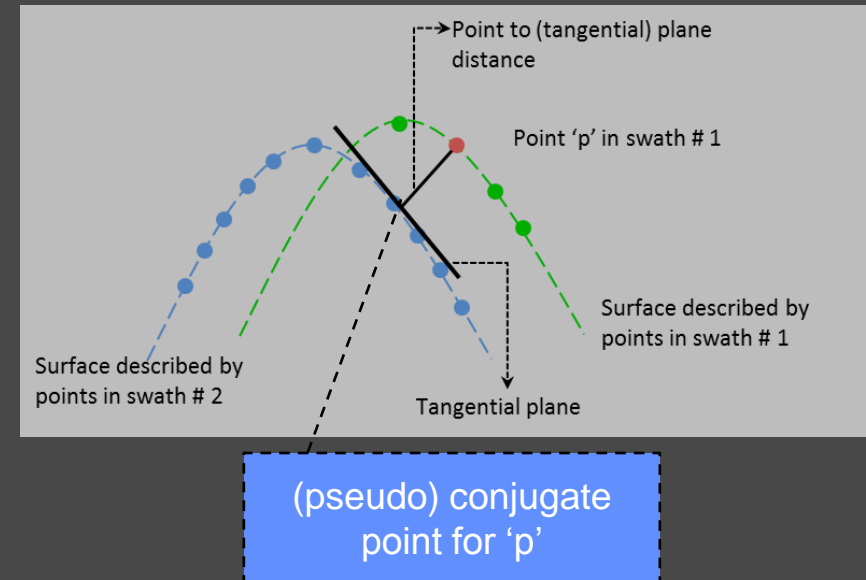


Inter Swath Accuracy

- **Quality of Calibration is most easily discerned in overlapping regions of swaths**
- **Current quality assessment specs are inadequate**
 - For e.g. no guidance on how to calculate relative accuracy, or acceptable measurements of relative accuracy, etc.
 - Does not mention quantifying systematic errors
- **Internal Data Quality Measures (DQM)**
 - Definitions of inter-swath measures
 - Prototype Research Software for DQM over Natural Surfaces
 - Test and Analysis

Relative Data Quality Metrics

- Intent of DQM:
Measure of Internal consistency of data
 - “Quantify this quality” in a consistent manner
 - Measured in overlapping regions of adjacent swaths
 - Point-to-Plane distance measures

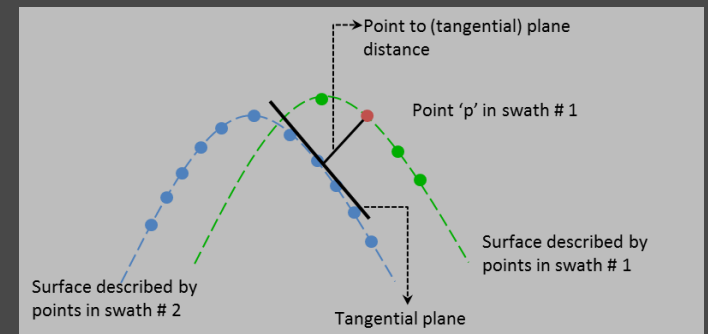
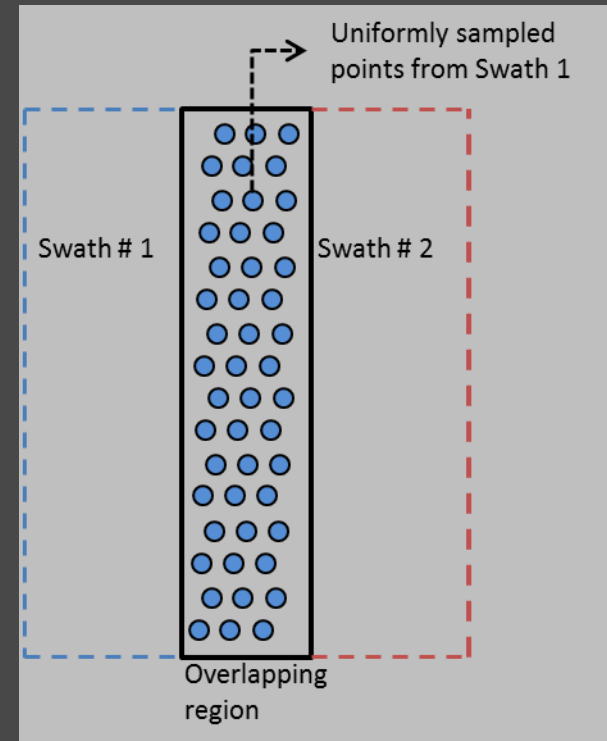


Recommended Data Quality Metrics

Nature of surface	Examples	Data Quality Measures (DQMs)/Goodness of fit measures
Natural surfaces	Ground surface, i.e. not trees, chimneys, electric lines etc.	Point to natural surface (tangential plane to surface) distance
		Point to surface vertical distance
Man-made surfaces	Roof planes	Perpendicular distance from the centroid of one plane to the conjugate plane
	Roof edges	Perpendicular distance of the centroid of one line segment to the conjugate line segment

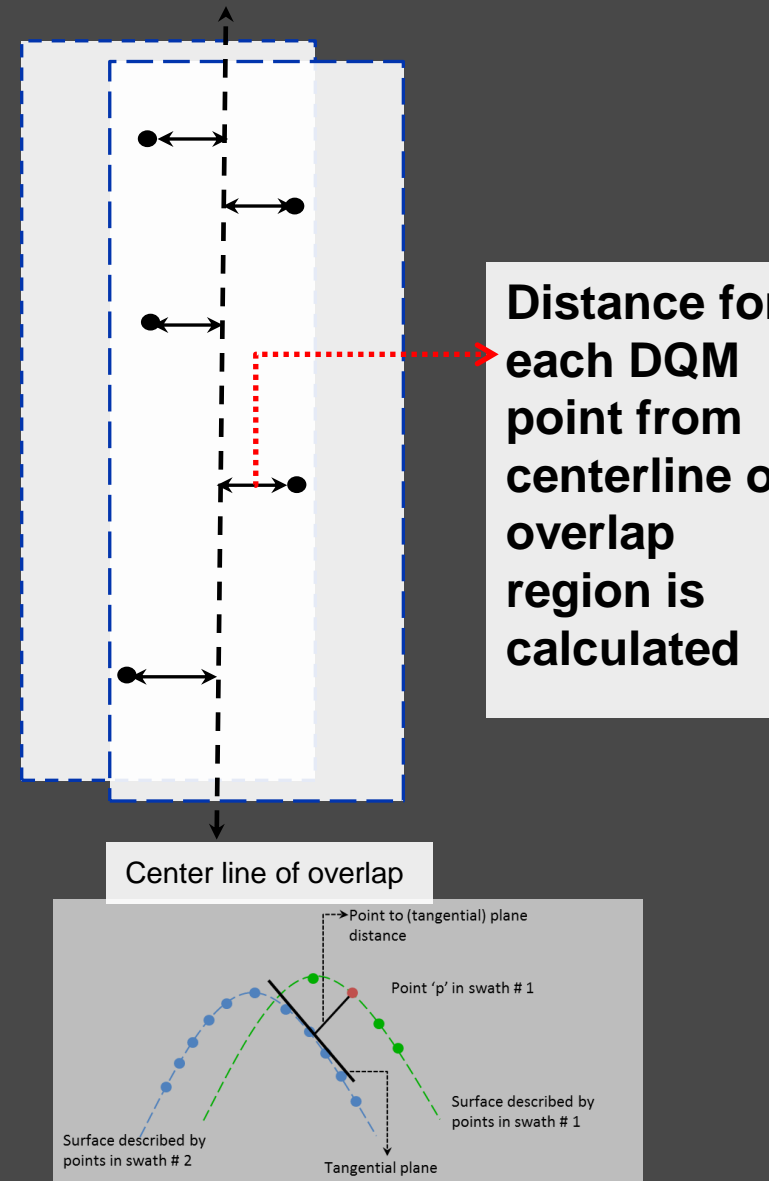
DQM over natural surfaces research software

- US Geological Survey has funded prototyping a research level implementation for the Working Group
- The prototype works on adjacent and multiple swaths
- Uniformly samples check points in overlapping region
- Determines DQM for each sample check point

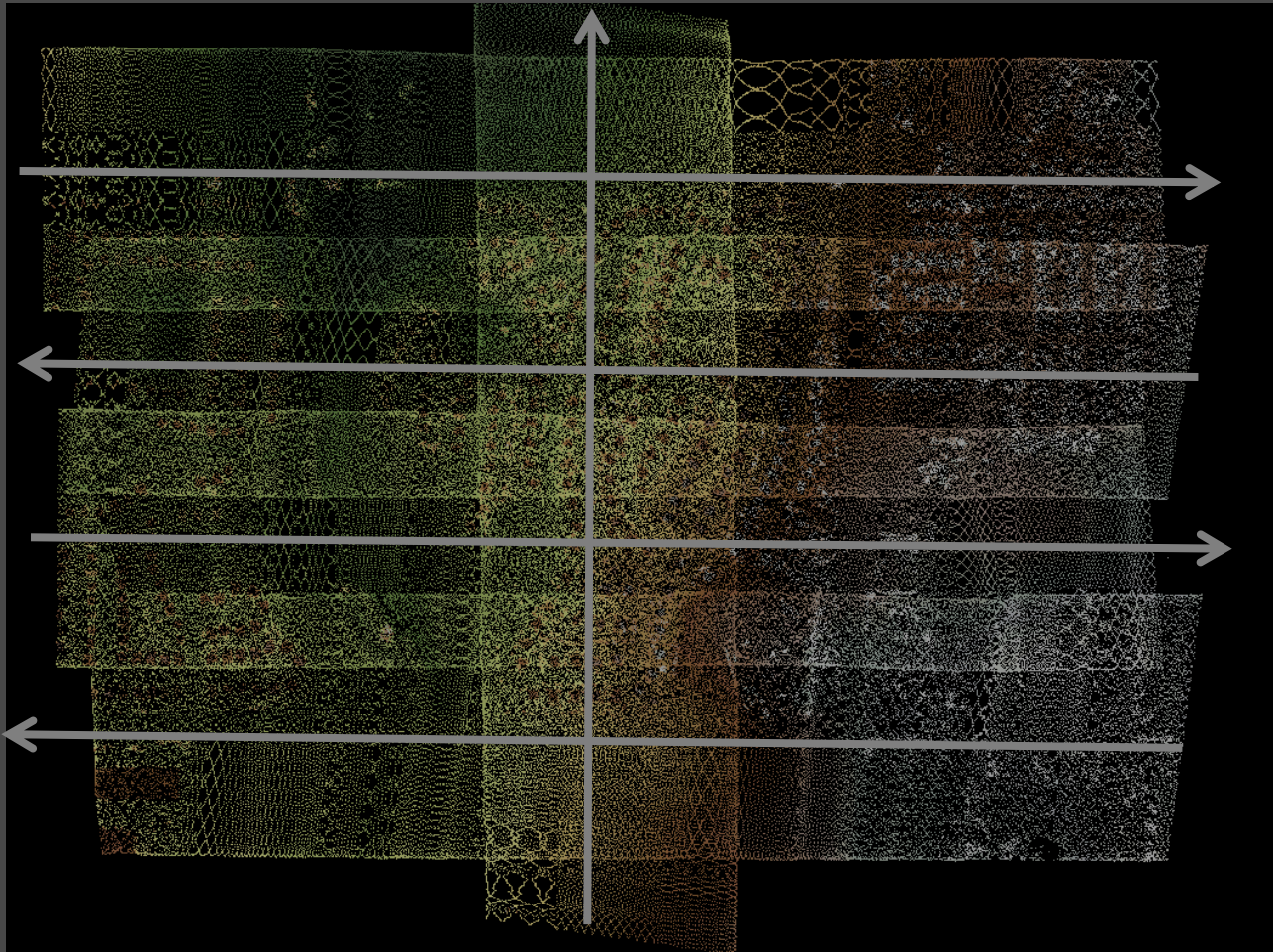


Mining Systematic Errors from DQMs

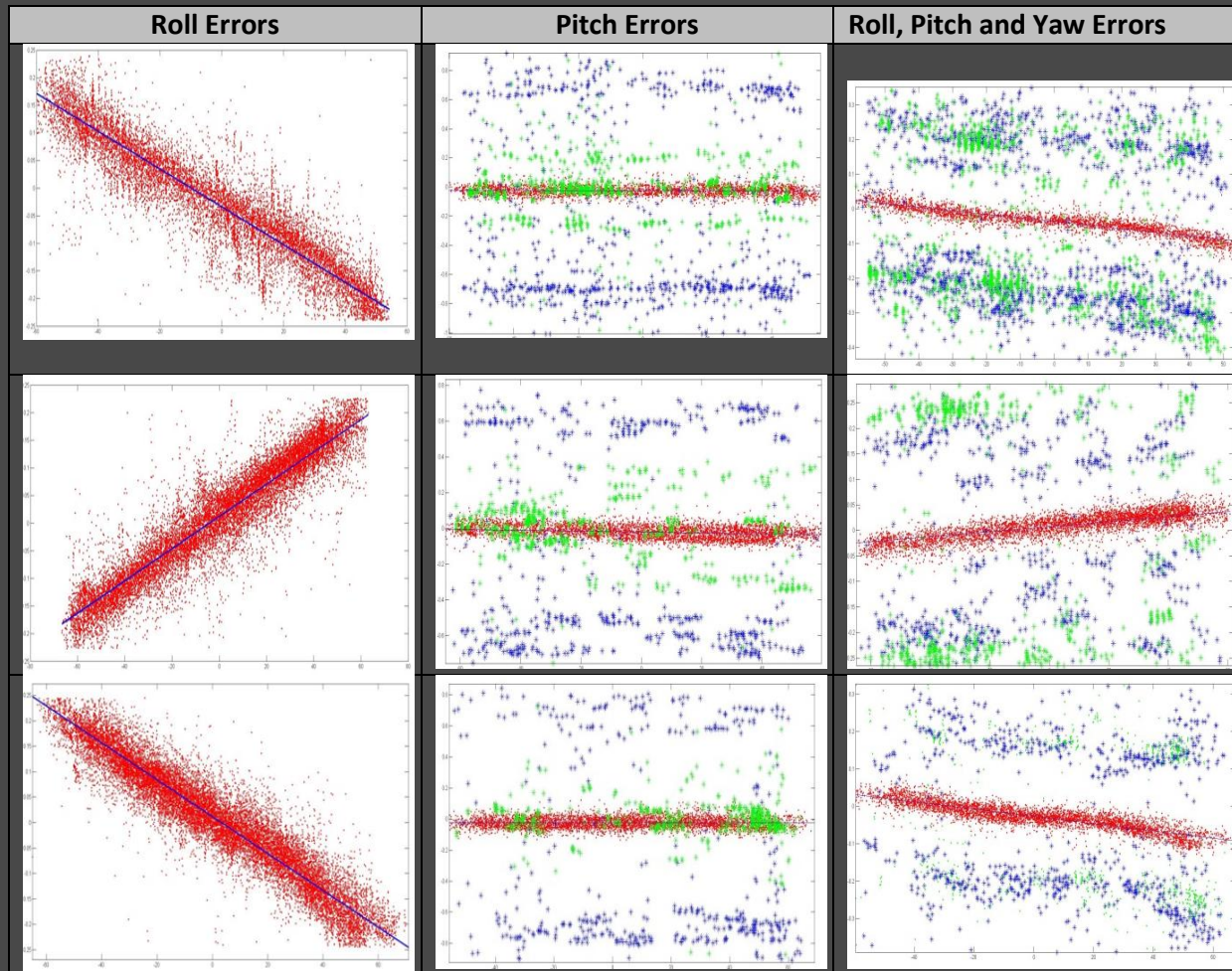
- Analysis mainly consists of DQM errors vs distance of sample check points from center of overlap
 - Center of overlap defined as line along the length of the overlap region passing through median of sample check points
- Distortion Angle:
 - $DA = \arctan(\text{DQM Error} / \text{Distance to center of Overlap})$
- Categorized RMSE
 - Based on underlying surface curvature/slope



Lidar data for Analysis: Courtesy Matt Bethel, Merrick

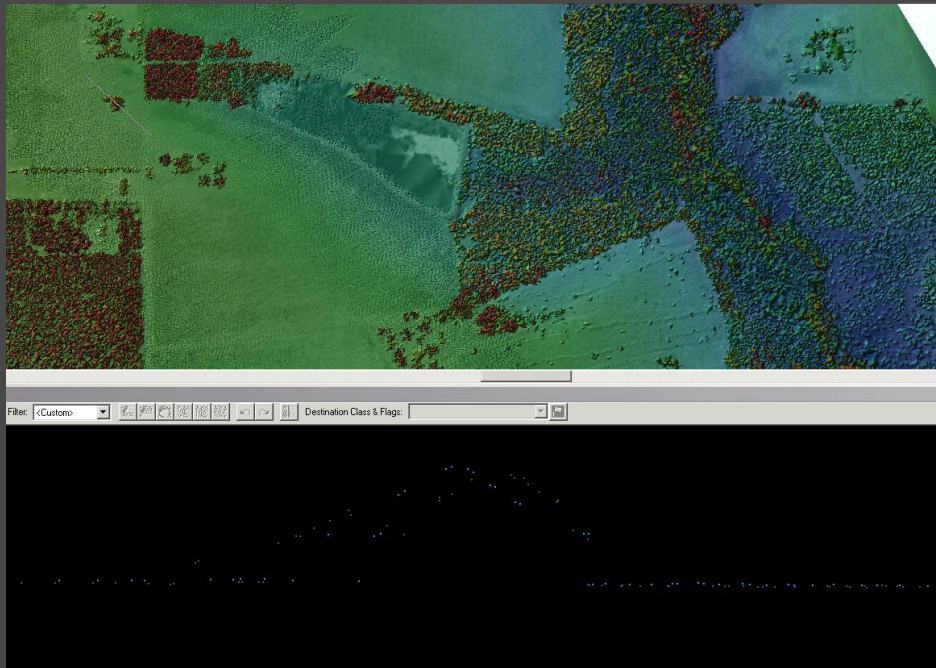
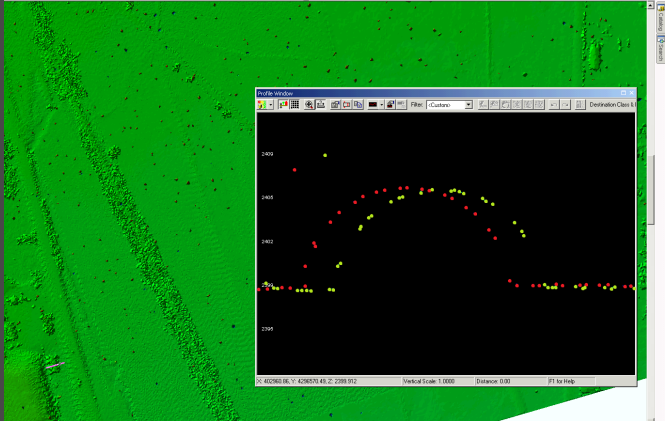
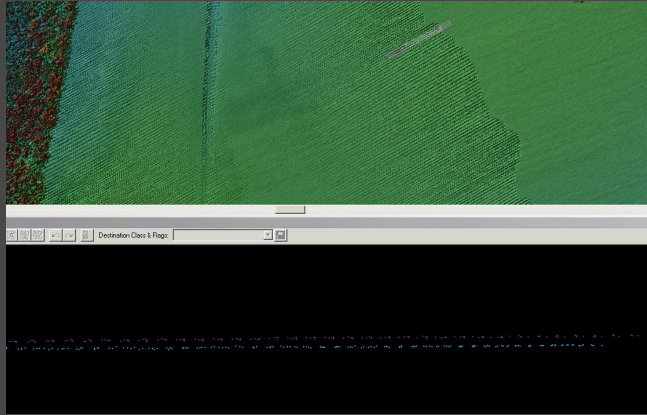
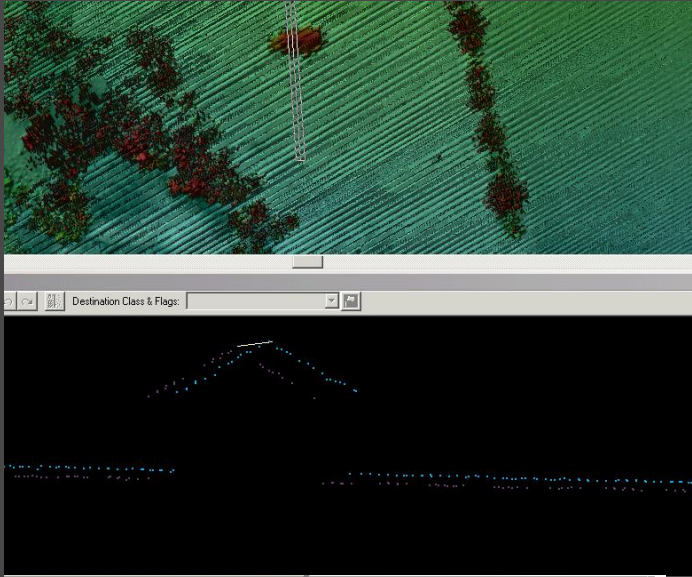


DQM Analysis



Further Tests

- Tested on Swath Data available with USGS
 - 5 data sets so far: CO, CA, GA, AL, FL
- Some swaths meet current specifications and some do not
- Discrepancy angles were measured
 - Data with higher discrepancy angles inspected visually
 - Indicates systematic errors



Future Work

- **New specifications based on tests are required to be implemented**
 - **With theoretical basis from point cloud analysis and not DEM**
- **New specifications may include**
 - **Median of Discrepancy Angles**
 - **Categorized RMSE based on Flat and Higher Slopes**
- **More spatial analysis of errors**
- **Absolute Accuracy**

Future Work

- Feature based comparison techniques can be developed for accuracy assessment
- The DQMs can be potentially used to trace errors back to Lidar Sensor for calibration
 - Requires understanding of sensor model
 - Requires raw data (including GPS/IMU)
- USGS-ASPRS Draft Guidelines
- For more information, please contact:
 - Greg Stensaas: stensaas@usgs.gov
 - Ajit Sampath: asampath@usgs.gov